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**TITLE: LOCATION SIGNALLING DEVICE**

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**Field of the Invention**

This invention pertains in general to the field of location signalling devices, and more particularly to signalling devices for locating e.g. equipment or persons in emergency and/or in need of being located and picked-up or rescued. Even more particularly, the invention relates to a signalling device rising above the location of a person in emergency or the location of equipment, thus facilitating rescue or pick-up operations. The location signalling device is intended for use by e.g. persons in an emergency situation, for instance persons lost overboard of vessels, persons stranded with emergency landed aeroplanes, or persons injured or lost in the wilderness, or equipment having e.g. finished a task and signalling its location for being picked-up.

**Background of the Invention**

One of the most difficult tasks of search and rescue (SAR) operations are marine rescue operations at night times and heavy weather. Locating a person swimming in the open ocean from larger distances is nearly impossible. Even when a rescue team, independently if situated on a vessel or in an air-bound rescue vehicle, is very close to the swimmer, the swimmer itself is hard to discover. This is caused by obstacles such as e.g. the ocean waves, rain, fog, and darkness. Ocean waves have mostly heights

exceeding the height of the swimmer over the water surface by multiple times. Land-based rescue operations, such as alpine rescue operations are another example of such difficult tasks.

5           Therefore, various types of signalling devices for signalling the position of persons in an emergency or for locating equipment have been proposed in the past.

For instance a warning and signalling system including a kite attached to a flexible rope is disclosed  
10 in US-4 768 739. The kite is used as an enhanced visibility warning and signalling device. The kite is carried aloft by blowing wind. However, a kite 12 always needs at least a certain amount of relative air movement, such as wind, in order to keep the kite at a certain height. This is  
15 illustrated in Figs. 1C and 1D. To keep the signalling device at a minimum height is essential for the efficiency of detecting persons in emergency. In situations of very calm weather or windless weather conditions, a kite will drop to the surface and not fulfil the signalling purpose.  
20 Moreover, a kite is sensitive to turbulence and gets easily unstable, which leads to the kite crashing down on the surface. This is a basic disadvantage of kites, limiting the range of use unnecessarily. Furthermore, for injured or handicapped persons it is not possible to launch a kite.

25           Therefore location and signalling balloon devices have been proposed, e.g. in US-4 944 242. A balloon body is in case of an emergency situation filled with a lighter-than-air gas from e.g. a pressurised container or a chemical reaction. The inflated balloon is fixed to a  
30 tether line, which is e.g. attached to the person in emergency or to the ground near that person, in order to

signal the position of that person to search and rescue (SAR) operations. However, balloons have a number of disadvantages when being used as signalling devices. Balloons are not suitable for use in windy weather

5 conditions in contrast to the above mentioned kites. With increasing wind velocity a balloon 1, fixed to a surface below by means of a tether line, will be drawn down to the surface due to the resulting force  $F_T$  on the balloon being dominated by the dragging force  $F_D$  of the wind on the

10 balloon. This is illustrated in Figs. 1A and 1B. The inclination angle  $\alpha$  decreases from no wind ( $v_w = 0$ ) with increasing wind  $v_w > 0$ . One possibility to solve this problem is to increase the size of the balloon being filled with gas. However, this option is very limited for the use

15 in emergency signalling kits. This is due to the fact that these kits should be as compact and lightweight as possible when not in use. This condition limits both the size of such a balloon and the amount of available gas for inflating the balloon.

20 In order to overcome the drawbacks of signalling devices being based on purely a kite or a balloon, it has been proposed to aerodynamically shape balloons in the form of a kite, e.g. in the patent application CA-A-2172852, or in the form of a wing, e.g. in US-4 815 677. US-3 657 752

25 discloses a locator device for locating submerged equipment having returned to the surface of an ocean. The device generates gas by a chemical reaction of a compound with water, whereupon the gas inflates a balloon-kite flying aloft tethered to a container at sea level. The balloon-

30 kite is radar-detectable and ascends into the air above the water by means of the buoyancy of the gas-filled part of

the balloon-kite and/or the aerodynamic lift of the kite part of the balloon-kite. This is illustrated in Figs. 1E and 1F. However, also these devices combining a kite or a wing with a balloon have certain undesired drawbacks. For

5 example it is desired that a dragging force that is exerted by the signalling device on the tether line is generally constant at the point where it is fixed to a person in emergency, a piece of equipment, or a ground surface. The dragging force should be constant within a certain limit.

10 This ensures on the one-hand that the above-mentioned dragging force of the signalling device does not exceed a maximum load of the tether line, thus preventing its rupture. A rupture of the tether line which would render the signalling device useless as the kite or the balloon

15 flowing away will no longer signal the desired location. In addition, a dragging force that comes close to or exceeds the weight of the equipment or person, whose position is to be signalled, will result in an undesired effect of moving the person or equipment. This may be a health hazard for

20 e.g. a person drawn through the water, causing the person to unintentionally get water into the respiratory system. Moreover, in case of e.g. a child or non-heavy equipment, the signalling balloon may draw the child or the equipment over the ground, when used on land, resulting in injuries

25 of the child or in damage of the equipment. In the worst case, the person or equipment will be raised out of the water or over ground. If the dragging force on the other hand becomes too low, the signalling device will not ascend sufficiently high and cannot fulfill its signalling

30 purpose.

A kite-balloon or a wing-balloon has the advantage that it remains aloft properly under windless or low wind conditions due to the lifting force of the lighter-than-air gas in the balloon. Moreover, at high wind conditions, the aerodynamic shape of the kite or the wing compensates for the downward force imposed on the signalling device. At high wind conditions, even these devices, notwithstanding the problem of tether-line-rupture, will become unstable due to turbulent behaviour of the kite or wing as mentioned above.

Thus, there is a need for a new signalling device based on a combination of a wing or kite with a balloon, avoiding the above-identified problems and ensuring a generally constant dragging force on the tether line.

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#### **Summary of the Invention**

The present invention overcomes the above-identified deficiencies in the art and solves at least the above-identified problems by providing a location-signalling device, and a method according to the appended patent claims.

The general solution according to the invention is to provide a wing balloon with a flexible wing portion. With increasing wind, the flexible wing portion bends, and the effective surface of the wing is decreased. Thus, the lifting force generated by means of the wing is reduced and the effect of increasing wind is compensated for. However, the signalling wing balloon works also in no-wind weather conditions by means of the balloon being filled with a lighter-than-air gas lifting the balloon. Bending of the wing is performed purely passively and no active means or

devices are necessary in the wing balloon to achieve the variable attack surface. Thus, a very compact package design of the location-signalling device is achieved.

More particularly, the present invention has the  
5 advantage over the prior art that it provides an emergency signalling device being more efficient than the known prior art devices. The signalling device according to the invention is usable over a wider range of weather conditions than previously known devices. Furthermore, the device  
10 according to the invention provides a generally constant dragging force on the tether-line, increasing safety of the device as well as comfort for the users of the device. Hence, the present invention has the advantage over the prior art that it is usable over a wide range of wind  
15 conditions without unduly increasing the load on a tether line of a location-signalling device.

Preferably, the wing balloon is easily visually detectable, thanks to the fact that the wing balloon having a distinct colour differing from the background. This  
20 colour is e.g. a highly visible fluorescent orange. Optionally, several such colours are arranged on the surface of the balloon, for instance in stripes or other shapes, in order to generate an as high as possible visually detectable contrast.

25 In addition to that, the wing is formed such that a "waving" movement pattern of the balloon is achieved. For instance, the balloon flies on an elliptical path, or on a path in the form of a "8". Thus, the visual detectability of the wing balloon is further enhanced.

Optionally, the wing balloon is equipped with a smoke generating means. This means release smoke from the wing balloon, thus increasing the distance of visibility.

Preferably, the wing balloon is fabricated from a  
5 material that reflects light upon illumination.

Furthermore, the wing balloon is preferably made of a radar reflective material or comprises radar reflective material or means, e.g. inside the balloon as radar reflective swatches, or as radar reflective stripes or  
10 tails of e.g. aluminium attached to the rear of the wing balloon. This enables the wing balloon to be detected by radar, which allows directional signal finding of the wing balloon providing its exact position or direction in relation to a search vehicle. Radar detection is given  
15 independently of the present weather conditions.

According to another preferred embodiment, the wing balloon is equipped with a chemical heating means. This provides detectability of the wing balloon in 3D by means of thermocameras.

20 The wing balloon according to the invention increases drastically the success rate of localisation and rescue missions and improves the survival chances of persons in emergency.

#### 25 **Brief Description of the Drawings**

Further objects, features, and advantages of the invention will become apparent from the following description of exemplary embodiments of the present invention, reference being made to the accompanying  
30 drawings, in which

Fig. 1A to 1F are schematic illustrations of a pure kite, a pure balloon and a wing balloon in different windy weather conditions;

Fig. 2 is a schematic illustration of a location-  
5 signalling device according to an exemplary embodiment of the invention in the non-inflated condition;

Fig. 3 is a schematic illustration showing the location signalling device of Fig. 2 with the wing balloon inflated and aloft;

10 Fig. 4A to 4C are schematic illustrations showing the wing balloon according to different embodiments of the invention;

Fig. 5 to 10 are photographic illustrations showing the wing balloon according to different embodiments of the  
15 invention; and

Fig. 11 is a schematic illustration of an exemplary inflated wing balloon.

### **Description of embodiments**

20 In an exemplary embodiment of the invention according to Fig. 2, a location-signalling device 2 is shown in the non-inflated condition. The device comprises a housing 20 and has approximately the size of a packet of cigarettes, although other designs, shapes, and sizes are possible,  
25 depending on the intended use as well as adherent conditions. The device comprises a fastening means 21, e.g. for fastening to an object such as a life saving jacket, a backpack, or other objects. The packet 2 contains an  
30 inflatable wing balloon 22. The wing balloon 22 is self-inflating upon activation, wherein the gas originates from a gas storage device 23, such as a gas cylinder containing



compressed gas. The size of the gas cylinder is adapted to the size of the inflatable volume of the wing balloon. For instance, the gas cylinder has to have a size of 1/200 of the wing balloon inner volume at a compression pressure of 200 bar of the gas inside the gas cylinder. The gas for inflating the wing balloon is a lighter-than air gas, preferably non-inflammable or health hazardous when inhaled, such as Helium. The inflation process is performed in a non-explosive way, such that neither the balloon or persons close to the device may be harmed or damaged. This improves as well acceptance of the device by its users, in contrast to e.g. airbag systems that inflate explosively. Preferably, a flow-limiting valve 24 controls the inflation process, so that the inflation process takes a couple of seconds.

Fig. 3 shows the location signalling device of Fig. 2 with the wing balloon aloft thanks to the buoyancy of the wing balloon filled with the above-described gas. The buoyancy principle is based on the fact that a body (=wing balloon) immersed in a fluid (=air) experiences a net upward force equal in magnitude to the weight of the fluid displaced by the body. Here the lighter-than-air gas displaces the heavier air.

The wing balloon is fixed to a tether line 30 keeping the wing balloon at a fixed distance relative a fixed position 31. However, the height above the level of the fixed position 31 depends on prevailing wind conditions and the resulting inclination angle  $\alpha$ . This height insures the detectability of the wing balloon and should not fall below a certain limit. Therefore, the tether line has a sufficient length, e.g. ca. 10-40m for marine rescue.

operations and ca. 50-100m for land based rescue operations, such as alpine rescue operations. Marine rescue or pick-up operations are often performed by using a helicopter. In this case, it is important that the line  
5 length is not too long, so that the wing balloon cannot get caught in the rotating helicopter blades. A suitable length for the tether line is about 10m in this case. Then the helicopter is, after locating the location signalled by means of the wing balloon, able to hover over the location  
10 at a sufficiently low height without risking incidents with rotor blades catching the tether line. Then the person or equipment in the water may be safely picked up by means of a lifting gear placed in the helicopter.

During land-based operations, the length of the  
15 tether line may be chosen longer, increasing the detection range of the wing balloon. This is due to the fact that e.g. a helicopter may land near the person or equipment to be picked-up, thus avoiding the helicopter blade related problems.

20 In all cases, the length of the tether line is to be chosen, such that the detection range of the wing balloon is as far-reaching as possible without causing other problems. The radar detection range of the location signalling device according to the invention is  
25 approximately 40-50 km with the above-mentioned line lengths. The wing balloon is preferably made of a signal reflecting material, wherein the range of signals reflected comprises light both visible and invisible as well as radar or radio waves. Preferably, the wing balloon is easily  
30 visually detectable at all weather conditions, thanks to the fact that the wing balloon having a distinct light

reflecting colour differing from the background. This colour is e.g. a highly visible fluorescent colour like orange or yellow, or any other luminescent colour including the range of phosphorescent colours. Optionally, several  
5 such colours are arranged on the surface of the balloon, for instance in stripes or other shapes, in order to generate an as high as possible visually detectable contrast.

Furthermore, the wing balloon is preferably made of a  
10 radar reflective material or comprises radar reflective material or means, e.g. inside the balloon as radar reflective swatches, or as radar reflective stripes or tails 32 of e.g. aluminium attached to the rear of the wing balloon. This enables the wing balloon to be detected by  
15 radar, which allows directional signal finding of the wing balloon providing its exact position or direction in relation to a search vehicle. Radar detection is given independently of the present weather conditions.

According to another preferred embodiment, the wing  
20 balloon is equipped with a chemical heating means. This provides detectability of the wing balloon in 3D by means of thermocameras.

Hence, the wing balloon is designed to have maximum passive detectability by means of visually and radar  
25 detectability.

Furthermore, the material of the wing balloon is preferably water-repellent so that the weight of the wing balloon does not increase by the weight of water soaked up in the material.

30 An Airfoil is generally a structure designed to create a reaction upon its surface from relative air.

movement relative to the structure. The wing balloon is shaped as an airfoil having a variable reaction upon its surface depending on the relative airflow velocity. More precisely, the wing has an effective 'attack' surface,  
5 which decreases with increasing airflow velocity. In this way, an increasing lifting force is compensated for. The lifting force of the tethered wing balloon is the upward force resulting from the sum of aerodynamic lifting forces, dragging forces and buoyancy of the wing balloon. In  
10 contrast, the lifting force of an aeroplane is purely the upward force created by a difference in air pressure on both sides of an airfoil. Thus, by varying the 'attack' surface of the wing balloon, the amount of lift is changed arbitrarily and the lift generated is variable in a  
15 specific way favourable for keeping the dragging force on the tether line generally constant. Static and dynamic upward rising force are balanced against each other to ensure this effect. This is explained by the principle of physics that the wing balloon strives to an equilibrium in  
20 which the sum of all the forces on the wing balloon equals zero.

Air moving over and under the wing balloon, as the air is flowing past the wing balloon due to wind, creates this difference in air pressure. This is because the air  
25 that moves over the top of the wing has farther to go because the wing is tilted slightly upward. The shape of the wing balloon is important for lift. A preferred shape is that the wing balloon has a curved, upper surface and a flatter, lower surface. The air has further to go around on  
30 the top of the wing balloon, whereas the bottom of the wing balloon is generally flat, so air does not have as far to

go. Due to the shape of the wing balloon, the air on the bottom can move faster to a certain point than the air on top. Difference of movement of air around the wing balloon creates this lift, and lift pushes the wing balloon against  
5 the downward force as explained above. However, at conditions with no relative air movement, the buoyancy is the only lifting force. Hence, the resulting lifting force is balanced between the two lifting forces, namely buoyancy and aerodynamic lifting force. This combines the advantages  
10 of both principles and ensures that the wing balloon is aloft over a wide range of wind conditions.

The wing balloon is designed that it becomes more and more arrow-shaped achieving the above-described dependency of the active wing surface on relative airflow velocity.  
15 Due to inherent flexibility, the wing balloon will revert to its original shape with decreasing relative airflow velocity. Thus it is achieved, that the wing balloon generates a generally static dragging force on the tether line in the range of 0-40 m/sec airflow velocity.

20 In order to stabilise the wing balloon in the roll direction, the wing balloon is preferably equipped with stabilising means such as tails attached to the back of the wing balloon. These tails serve primarily the aerodynamic purpose of stabilising the wing balloon. Furthermore, these  
25 tails may be made of a radar-reflective material, such as aluminium strips or tinfoil strips, so that they even fulfill the purpose of radar/detectability.

It has to be pointed out that the wing balloon does not comprise any active control devices such as  
30 electronics, power sources such as batteries, or active

mechanical elements, such as wing surface varying means known from e.g. supersonic aeroplanes.

The wing balloon is fixed to a tether line, e.g. a strong nylon thread or string, having an appropriate  
5 length, in the range between 20m and 100 m, e.g. 30m. The tether line itself is attached or fixed to a fixpoint, such as an individual person, equipment, or a location. The lifting force of the wing balloon is preferably designed such that at wind speeds of 33 m/sec the wing balloon does  
10 not turn down more than 45 degrees from the vertical plane seen from the fixpoint.

In addition to the above-mentioned, the wing is preferably formed such that a "waving" movement pattern of the balloon is achieved at wind speeds above a certain  
15 lowest limit. For instance, the balloon flies on an elliptical path, or on a path in the form of a "8". Thus, the visual detectability of the wing balloon is further enhanced. A waving movement is easier to detect from a large distance.

20 Optionally, the wing balloon is equipped with a smoke generating means. This means release smoke from the wing balloon, thus increasing the distance of visibility.

Preferably, the wing balloon is fabricated from a material that reflects light upon illumination.

25 Fig. 4A to 4C are schematic illustrations showing the wing balloon according to different embodiments of the invention. Fig. 4A shows a wing balloon 4 having a central inflatable body 41, side wings 42, 43 and tails 51. With increasing relative air movement  $v_w$ , the side wings 42, 43  
30 move in the direction of arrows 47, 44 and 45, 46 respectively, i.e. in this case an upward inward movement

decreasing the attack area of wing balloon 4 in relation to the relative air movement  $v_w$ . Fig. 4B shows a wing balloon 5 having an arrow shaped inflatable body 48, side wings 49, 50 and tails 52 on each of the side wing's ends. With  
5 increasing relative air movement  $v_w$ , the side wings 49, 50 move in the direction of arrows 55, 56, i.e. in this case an inward movement decreasing the attack area of wing balloon 5 in relation to the relative air movement  $v_w$ . Fig. 4C shows a wing balloon 6 in a side cross-sectional view.  
10 The wing balloon 6 has an inflatable body 58 and tails 53. With varying relative air movement  $v_w$ , the rear portion of wing 6 moves in the direction of arrow 57 respectively, i.e. in this case an inward movement decreasing the attack area of wing balloon 4 in relation to increasing relative  
15 air movement  $v_w$  and vice versa.

Fig. 5 to 10 are photographic illustrations showing the a variety of different exemplary wing balloons according to different embodiments of the invention, at least partly corresponding to Figs. 4A to 4C.

20 Fig. 11 is a schematic illustration of an exemplary inflated wing balloon 110 having a tail 112, being tied to a tether line 111. Flexible wing portions 113, 114 comprise adjacent inflated 113, 114 and non-inflated chambers 115, 116, wherein said inflated chambers 113, 114 and 119  
25 respectively being connected to each other through conduits 120, 121 in said non-inflated chambers 115, 116. Thus, the flexibility is achieved resulting in the resilient behaviour of wings 113, 114 achieving the variable attack surface of wing balloon 110.

30 A further way of achieving the resilient flexibility of a wing balloon is to vary the thickness of the wing

balloon material appropriately. A thinner wall results in an easier to bend section of a wing and vice versa.

When during e.g. SAR operations a person in emergency has been located thanks to the location signalling device of the invention, often the wing balloon is released by cutting off the tether line. This is most often performed by the rescue person being dropped from e.g. a vessel or a helicopter, then swimming to the person and taking care of the further pick-up proceeding. At this point the wing-balloon is released and flies away. In this condition the wing balloon may be a risk for air traffic, damaging airborne vehicles. In this case the wing balloon is optionally equipped with a pressure release means, releasing the lighter-than-air gas from the inflated wing balloon. The pressure release valve is passively activated by an increasing pressure in relation to the surrounding pressure. The surrounding pressure decreases with increasing height, approx. 1 mbar per 3 m. Alternatively this relative pressure difference caused by the balloon rising, may cause the balloon to explode. For instance, at a height of 450m, the pressure difference is 15mbar. This pressure difference as a release pressure is sufficient to ensure reliability of the location signalling device avoiding deflating by mistake. After deflating or exploding, the residual elements are no longer a potential danger for air-traffic. From an environmental point of view the wing balloon may in this case be made from a biodegradable material.

Applications and use of the above-described location-signalling device according to the invention are various and include exemplary fields such as SAR operations of e.g.



seamen, mountaineers, or skiers in need of being rescued. Potential users of the device are persons, which may get into life-threatening emergency situations at more or less remote locations, at which the persons life depends on  
5 being detected and rescued by third persons. Such persons are e.g. the above-mentioned, but also the rescuers themselves, i.e. SAR operators, pilots of aeroplanes and helicopters, rescue or life-saving service operators such as sea rescue or coastguard service operators. Another  
10 application is to have the emergency kit integrated in life vests available on passenger boats and other vessels, readily available in case of emergency, when a life-vest is put on by persons as a routine safeguard or during emergency cases.

15 Another application is the location of equipment. One example of many possible is to equip an oil sample-taking device that is dropped from airborne vehicles into the sea where oil contamination has been detected. The device takes oil samples from the surface for a later analysis in order  
20 to identify the cause or source of the contamination. Then the device has to be re/collected, whereby it is already a difficult task to locate the device due to the waves of the sea. Another problem is to collect the device. Both problems may be solved by means of the localisation  
25 signalling device according to the present invention. A signalling wing balloon connected to the sampling device by means of a tether line helps locating the sampling device. Furthermore, the tether line may be constructed from such strong material, that it is possible to collect the device  
30 by drawing it up from the sea with the tether line. This application is based on finding equipment that e.g. has

fulfilled a certain purpose and there is an interest for re-collecting the equipment due to e.g. economical or environmental purposes. Another example in addition to the above-mentioned is e.g. a test torpedo shot from a  
5 submarine. The test torpedo is easily located by means of the location signalling device according to the invention, when it has stopped and shall be picked-up for re-use.

A further application is to signal the location of equipment which has broken down, has crashed or which has  
10 been damaged on its travel. Therefore the position is unknown and most often the object is lost. By means of the location signalling device according to the invention, the position is easily detectable.

Yet another application is to mark a certain  
15 location. For instance, the location signalling device according to the invention may be dropped from a fixed wing or rotary wings aircraft that has located a certain object or person. The location signalling device is then dropped at the position and inflates the wing balloon, thus  
20 signalling this location. The object or person may then be easily located and picked up from e.g. a vessel or a motor vehicle, or a fixed wing or rotary wings aircraft depending on the nature of the location. The present invention has been described above with reference to specific  
25 embodiments. However, other embodiments than the preferred above are equally possible within the scope of the appended claims, e.g. different wing shapes than those described above, etc.

Furthermore, the term "comprises/comprising" when  
30 used in this specification does not exclude other elements or steps, the terms "a" and "an" do not exclude a plurality

and a single processor or other units may fulfil the functions of several of the units or circuits recited in the claims.